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NATIONAL DAM SAFETY PROGRAM, BROADBODUS DAM

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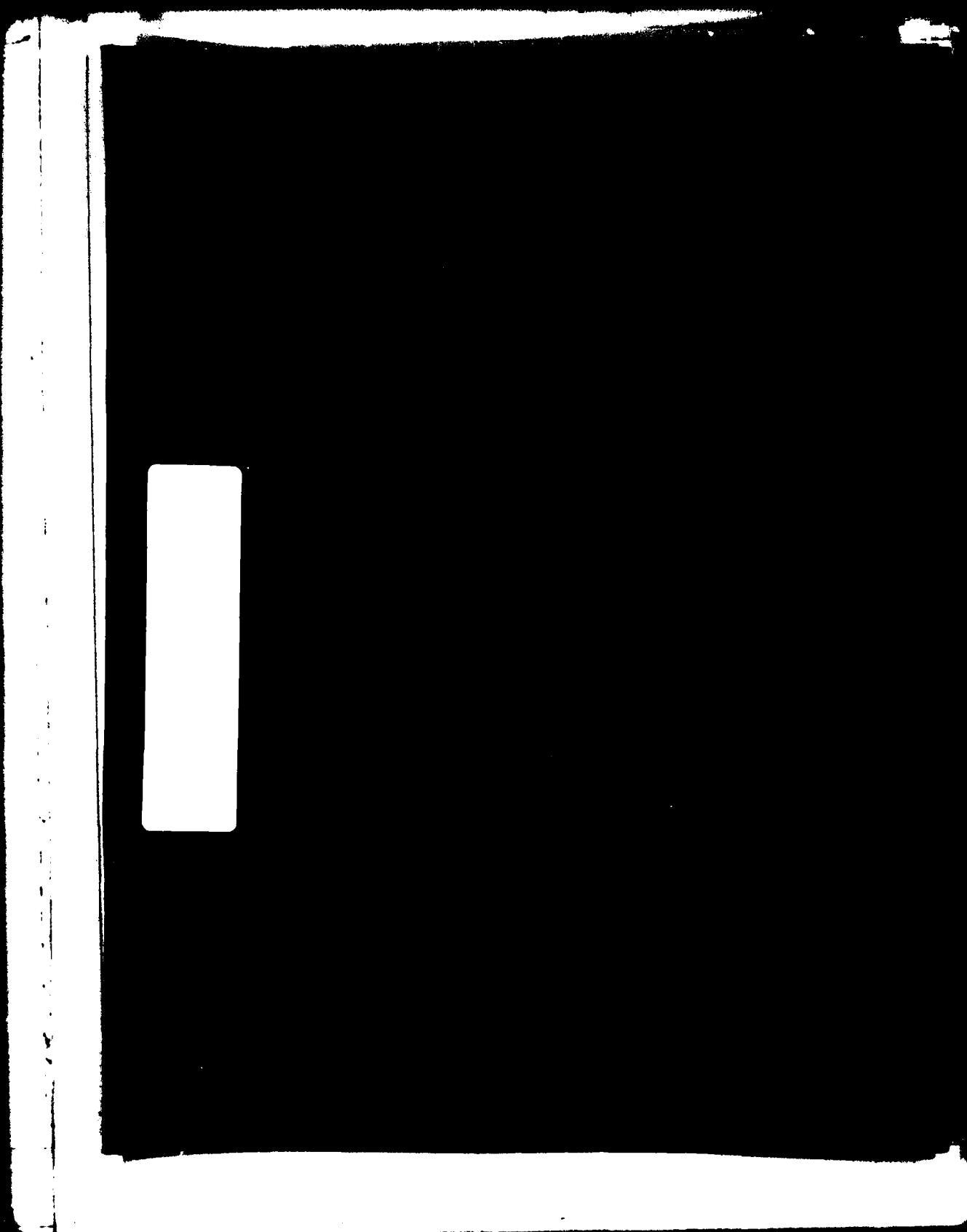
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## 20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.



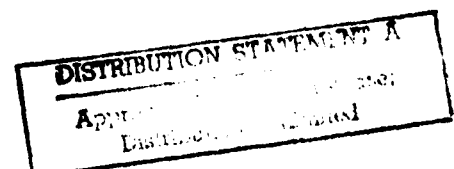
## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition, and the downstream damage potential.



PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

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⑥ National Dam Safety Program  
Broadus Dam (Inventory Number VA03917)  
York River Basin, Caroline County,  
Commonwealth of Virginia  
Phase I Inspection Program

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⑮ DACN65-80-D-0032

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NAME OF DAM: BROADDUS DAM

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PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Broaddus Dam  
State: Commonwealth of Virginia  
County: Caroline  
USGS 7.5 Minute Quadrangle: Bowling Green, Virginia  
Stream: Maracossic Creek  
Date of Inspection: 8 July 1980

BRIEF ASSESSMENT OF DAM

Broaddus Dam is an earthfill embankment approximately 11.3 feet high<sup>1</sup> and 500 feet long with spillways consisting of two 48 inch diameter reinforced concrete pipes adjacent to the left<sup>2</sup> abutment and a single 48 inch diameter reinforced concrete pipe adjacent to the right abutment. The dam, located approximately 0.2 miles north of Bowling Green, Virginia, is used for recreation. The dam is owned by Mr. Charles N. Broaddus, Mr. Russell G. Broaddus, Mrs. Linda B. Luck, and by the Virginia Department of Highways and Transportation. Broaddus Dam is a "small" size - "significant" hazard structure as defined by the Recommended Guidelines for Safety Inspection of Dams.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the 100-year flood was selected as the spillway design flood (SDF). The SDF was routed through the reservoir and found to overtop the dam by a maximum depth of 2.8 feet with an average critical velocity of 7.7 feet per second. Total duration of overtopping would be approximately 9.5 hours. The spillways are capable of passing only 1 percent of the Probable Maximum Flood without overtopping the crest of the dam. The spillways are adjudged as inadequate. The spillways have not been adjudged as seriously inadequate since there is not a high probability of loss of life due to large flows downstream of the dam, and because failure of the dam due to overtopping would not significantly increase the probability of loss of life.

Based on the inadequacy of the spillways, the apparent stability problems in the area of the left spillway, and the poor condition of the downstream slope, the dam is assessed as "unsafe", "non-emergency."

<sup>1</sup>Measured from the streambed at the downstream toe to the embankment crest.

<sup>2</sup>Facing downstream.

NAME OF DAM: BROADDUS DAM

A qualified geotechnical engineering firm should be retained to perform a stability check of the dam. The owner is required to engage the services of a qualified geotechnical engineering firm within two months of the issuance of the approved Phase I Inspection Report. The owner is required to have the consultant's report and to have reached an agreement with the Commonwealth of Virginia regarding required remedial measures within six months of the date of the issuance of the approved Phase I Inspection Report.

The consultant's stability check should include a detailed investigation of the apparent stability problems (sagging of the pipes, development of the hole in the embankment, sloughing, leakage) in the area of the left spillway. The consultant's report should include an explanation of the causes of the problems as well as recommended remedial measures.

A formal warning system and emergency action plan should be developed and put into effect as soon as possible.

The following repair items should be accomplished as part of the general maintenance of the dam:

- 1) The branches, logs, tree stumps, and garbage on the downstream slope should be removed.
- 2) All trees on the downstream slope should be cut off at ground level. All trees with a trunk diameter greater than 3 inches should also have their root systems removed. The resultant holes should be backfilled with compacted fill.
- 3) The hole in the downstream slope above the left spillway should be filled and compacted; the area of sloughing immediately above the hole should be regraded and compacted.
- 4) All areas of erosion should be regraded and compacted.
- 5) A good grass cover should be established over the entire embankment.
- 6) The leakage from under the right-hand pipe of the left spillway culvert should be stopped.
- 7) The concrete slabs at the downstream end of the left spillway culvert and under the 24 inch corrugated metal pipe which discharges directly downstream of the culvert should be repaired.

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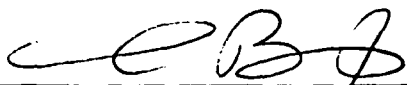


- 8) A staff gage should be installed to monitor  
reservoir levels above normal pool. Original signed by  
JAMES A. WALSH

MICHAEL BAKER, JR., INC.

SUBMITTED:

James A. Walsh, P.E.  
Chief, Design Branch



Michael Baker, III, P.E.  
Chairman of the Board and  
Chief Executive Officer

RECOMMENDED:

Original signed by  
JACK G. STARR

Jack G. Starr, P.E.  
Chief, Engineering



APPROVED:

Original signed by:  
Douglas L. Haller

Douglas L. Haller  
Colonel, Corps of Engineers  
District Engineer

Date:

SEP 19 1980

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NAME OF DAM: BROADDUS DAM



OVERALL VIEW OF DAM

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PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
NAME OF DAM: BROADDUS DAM ID# VA 03317

SECTION 1 - PROJECT INFORMATION

1.1 General

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams. The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

1.2.1 Description of Dam and Appurtenances: Broaddus Dam is an earthfill embankment approximately 11.3 feet high<sup>1</sup> and 500 feet long. The upstream and downstream embankment slopes are both approximately 2H:1V (Horizontal to Vertical). The crest of the dam is 29 feet wide. There is no information available on any possible zoning of the embankment. There is no slope protection on the embankment.

The dam has two spillways. The left<sup>2</sup> spillway is located adjacent to the left abutment. The approach channel for the left spillway is approximately 10 feet long, with an adverse slope of approximately 4H:1V. Several courses of concrete bars (8 in. by 6 in. by 10 ft.) have been placed at the control section to raise the level of the reservoir. The invert

<sup>1</sup>Measured from the streambed at the downstream toe to the embankment crest.

<sup>2</sup>Facing downstream.

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NAME OF DAM: BROADDUS DAM

elevation of the weir formed by the concrete bars is 152.6 feet<sup>3</sup> Temporary Bench Mark (T.B.M.). With the bars removed, the control elevation would be approximately 151 feet T.B.M. Piles of broken gneiss rock approximately 2-3 feet high have been placed on either side of the concrete bars. After flowing over the control section, the discharge flows along an earth channel with a natural rock bottom for approximately 25 feet and then enters a culvert which passes under the dam. The culvert consists of two 48 inch diameter reinforced concrete pipes 51 feet long. After leaving the culvert, the discharge flows over a concrete slab, approximately 10 feet long, then down a natural channel which is approximately 100 feet long.

The dam was originally constructed to provide water to power a mill. The right spillway is the old mill race. The approach channel is approximately 20 feet long by 4 feet wide, with no appreciable slope. A pile of broken gneiss rock has been placed in and on both banks of the mill race to raise the level of the lake above the channel invert elevation of 151.0 feet T.B.M. Water passes through the pile of rock (only a small amount of water passes through the pile of rock) then flows along a narrow channel with a very gentle slope for a distance of approximately 80 feet before entering a culvert which passes under the dam, adjacent to the right abutment. The culvert consists of a single, 30 foot long, 48 inch diameter reinforced concrete pipe. Water emerging from the culvert drops 4 feet into a narrow channel, which continues for about 100 feet.

There are no facilities for draining the reservoir.

- 1.2.2 Location: Broadus Dam is located on Maracossic Creek, approximately 0.2 mile north of Bowling Green, Virginia. A Location Plan is included with this report (Appendix I).

<sup>3</sup>All elevations are referenced to a Temporary Bench Mark (T.B.M.), which is approximately Mean Sea Level.

- 1.2.3      Size Classification: The height of the dam is 11.3 feet; the reservoir storage capacity at the crest of the dam (elevation 155.3 feet T.B.M.) is 240 acre-feet. Therefore, the dam is in the "small" size category as defined by the Recommended Guidelines for Safety Inspection of Dams.
- 1.2.4      Hazard Classification: A two-lane asphalt road runs along the crest of the dam. This road provides access to a residence, a church, and two cemeteries. U.S. Route 301, a four-lane divided highway, crosses the stream on an embankment approximately 0.3 miles downstream of the dam. There are three houses approximately 1.3 miles below the dam, but the U.S. Route 301 embankment would greatly attenuate any flood wave resulting from the failure of the dam. Therefore, loss of human life in the event of a dam failure is not considered highly probable. Appreciable economic losses due to damage to the two roads are likely in the event of a dam failure. Broadus Dam is therefore considered in the "significant" hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.
- 1.2.5      Ownership: The dam is owned by Mr. Charles N. Broadus, 815 Oak Hill Drive, Harrisonburg, Virginia 22801; Mr. Russell G. Broadus, 127 Longview Lake Drive, Raleigh, North Carolina 27610; Mrs. Linda B. Luck, P.O. Box 406, Ashland, Virginia 23005; and by the Virginia Department of Highways and Transportation.
- 1.2.6      Purpose: The dam is used for recreation.
- 1.2.7      Design and Construction History: According to Mr. Charles N. Broadus, the dam was originally constructed over 200 years ago. The reinforced concrete pipe culverts were probably emplaced sometime during the early 1950's. No other information on design and construction history was available.
- 1.2.8      Normal Operational Procedures: The reservoir is normally operated at the crest of the control section in the left spillway, elevation 152.6 feet T.B.M. No formal operating procedures are followed for this structure.

NAME OF DAM: BROADUS DAM

### 1.3 Pertinent Data

1.3.1 Drainage Area: The drainage area tributary to the dam is 6.12 square miles.

1.3.2 Discharge at Dam Site: The maximum discharge from the reservoir is unknown.

Left Spillway:

Pool level at top of dam . . . . . 145 c.f.s.

Right Spillway:

Pool level at top of dam . . . . . 114 c.f.s.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are provided in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

Item	Elevation feet T.B.M.	Area acres	Reservoir Capacity		Length feet
			Acre- feet	Watershed inches	
Top of Dam (minimum)	155.3	55	240	0.7	6800
Left Spillway Invert	152.6	39	114	0.4	6500
Right Spillway Invert	151.0	29	68	0.2	6300
Streambed at Toe	144.0	-	-	-	-

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## SECTION 2 - ENGINEERING DATA

- 2.1 Design: Design plans, specifications, and boring logs were not available for use in preparing this report. No stability analyses or hydrologic and hydraulic data were available for review.
- 2.2 Construction: Construction records, as-built plans, and inspection logs were not available for review. The reinforced concrete pipe culverts were probably emplaced sometime during the early 1950's.
- 2.3 Evaluation: No construction records or as-built plans were available to adequately assess the condition of the dam. All evaluations and assessments in this report were based upon field observations, conversations with representatives of the owner, and office analyses.

NAME OF DAM: BROADDUS DAM

## SECTION 3 - VISUAL INSPECTION

### 3.1 Findings

3.1.1 General: The field inspection was conducted on 8 July 1980. At the time of the inspection, the pool elevation was 153.0 feet T.B.M.; the tailwater elevation was 144.6 feet T.B.M.; and the weather was mild and rainy with temperatures in the mid 70's°F. The ground surface at the embankment and abutments was generally wet, due to a heavy shower just prior to the inspection. The dam and appurtenant structures were found to be in fair to poor overall condition at the time of the inspection. Deficiencies found during the inspection will require further investigation and remedial treatment. The following are brief summaries of deficiencies found during the inspection. A Field Sketch of conditions found during the inspection is presented as Plate 1. The complete visual inspection check list is given in Appendix III. No record of any previous inspections was found.

3.1.2 Dam: The embankment was found to be in generally fair to poor overall condition. The downstream embankment slope is eroded in places, particularly in the middle of the dam, and very uneven. The downstream slope is covered with branches, logs, tree stumps, and garbage. Consequently, a close inspection was impossible. There are many small- to medium-sized trees on the downstream slope, which also supports a thin cover of wild grass and weeds. The upstream slope has a good cover of wild grass and appears to be in good condition.

A hole approximately 3 feet in diameter by 4 feet deep has formed in the downstream embankment slope directly above the culvert of the left spillway. There is an area of sloughing 7 feet long by 4 feet wide directly above the hole. Both of the concrete pipes that form the left spillway culvert are curved, with the concave side upward, as if they have sagged since they were installed. At the time of the inspection, water was leaking from under the bottom of the right-hand pipe. This combination of deficiencies

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in the same area indicates that there may be a serious stability problem, which should be investigated without delay.

A wet area, approximately 40 feet long by 60 feet wide, was found approximately 25 feet downstream of the toe and 100 feet from the right abutment. A small area of standing water was found along the right abutment 50 feet downstream of the toe. No seeps were found on the downstream slope or at the toe.

There is minor erosion at the junction of the downstream embankment slope and left abutment, on the left side of the left spillway. Otherwise, the junctions of the embankment and abutments appear to be in good condition.

No evidence of an internal drainage system was found during the inspection.

3.1.3

Appurtenant Structures: The approach channel for the left spillway is approximately 10 feet long, with an adverse slope of approximately 4H:1V. Several courses of concrete bars (8 in. by 6 in. by 10 ft.) have been placed at the control section to raise the level of the reservoir. Piles of broken gneiss rock approximately 2-3 feet high have been placed on both sides of the concrete bars. The individual pieces of rock are angular and 1-3 inches in diameter. After flowing over the control section, the discharge flows along on earth channel with a natural rock bottom for approximately 25 feet before entering a culvert which passes under the dam, adjacent to the left abutment. The culvert consists of two 51 foot long, 48 inch diameter reinforced concrete pipes. After leaving the culvert, the discharge flows over a concrete slab approximately 10 feet long, then down a natural channel approximately 100 feet long. The discharge then enters a swampy area with no well-defined channel. Approximately 10 feet upstream of the culvert inlet there is a 24 inch diameter corrugated metal pipe which discharges surface runoff from the left hillside into the spillway. The concrete slab downstream of the culvert outlet is cracked and broken. There is moderate erosion on the downstream embankment slope on both sides of the culvert. Both of

the concrete pipes that form the culvert are curved, with the concave side upward, as if they have sagged since they were installed. At the time of the inspection, water was leaking from under the bottom of the right-hand pipe. There is another 24 inch diameter corrugated metal pipe which discharges from the left abutment directly downstream of the culvert outlet. Erosion has occurred around this pipe, the last 5 feet of which are now exposed and unsupported. The concrete slab which originally supported this pipe has eroded and washed away.

The dam was originally constructed to provide water to power a mill. The right spillway is the old mill race. The approach channel is approximately 20 feet long by 4 feet wide, with no appreciable slope. A pile of broken gneiss rock has been placed in and on both banks of the mill race to raise the level of the reservoir. The individual pieces of rock are angular and vary in length from less than 1 inch to 10 inches. At the time of the inspection, a small amount of water was flowing through the pile of rock; water also appeared to be undercutting the bank and flowing around the pile of rock. Water passing the pile of rock flows along a narrow channel with a very gentle slope for a distance of approximately 80 feet before entering a culvert which passes under the dam, adjacent to the right abutment. The culvert consists of a single, 30 foot long, 48 inch diameter reinforced concrete pipe. Water emerging from the culvert drops 4 feet into a narrow channel, which continues for approximately 100 feet before disappearing into a swampy area with no well-defined channel. The right spillway appears to be in good condition except where the water is undercutting the bank in the area of the rock pile.

There are no emergency gates or other facilities for draining the reservoir.

#### 3.1.4

Reservoir Area: The slopes surrounding the reservoir are gentle. There is a small cemetery on the left side of the reservoir immediately above the dam; this area has a good cover of short grass. The rest of the

NAME OF DAM: BROADDUS DAM

slopes around the reservoir are densely wooded. The slopes appear to be in good condition with no evidence of erosion. The extent of sedimentation was not directly observed, but it is not expected to be significant. According to a local resident, the reservoir has an average depth of 6-7 feet.

3.1.5 Downstream Channel: The discharge channels of both spillways are well-defined with no obstructions for a short distance below the dam. They then enter a swampy area where no well-defined channel exists. There is no appreciable slope in the swampy area downstream of the dam. The side slopes are heavily wooded.

3.1.6 Instrumentation: There is no instrumentation at the dam site.

3.2 Evaluation: In general, the dam and appurtenant structures are in fair to poor overall condition. The branches, logs, tree stumps, and garbage on the downstream slope should be removed. All trees on the downstream slope should be cut off at ground level. All trees with a trunk diameter greater than 3 inches should also have their root systems removed. The resultant holes should be backfilled with compacted fill. All eroded areas should be regraded and compacted. A good grass cover should be established over the entire embankment.

During periods of high reservoir levels, erosion is likely to occur at the control section of the left spillway. The piles of rock have been placed to prevent erosion, but the individual pieces appear to be small enough to be carried away by fast-moving water.

The water which is undercutting the bank and flowing around the rock pile in the right spillway may eventually cause the bank to collapse, which may lower the reservoir level. However, it will not have an adverse effect on the dam itself.

Further investigations to determine if there is a stability problem in the area of the left spillway should be made without delay. The hole in the downstream slope above the left spillway should be filled and compacted. The area of sloughing immediately above the hole should be regraded and compacted. The leakage from under the right-hand pipe should be stopped. The concrete slabs at the downstream end of the left spillway

NAME OF DAM: BROADDUS DAM

culvert and under the 24 inch corrugated metal pipe which discharges directly downstream of the culvert outlet should be repaired.

A staff gate should be installed to monitor reservoir levels above normal pool.

NAME OF DAM: BROADDUS DAM

#### SECTION 4 - OPERATIONAL PROCEDURES

- 4.1 Procedures: Operation of the dam is an automatic function controlled by the left and right spillways. Water entering the reservoir flows through the right spillway at elevation 151.0 feet T.B.M. When the inflow is sufficient, the reservoir level rises above elevation 152.6 feet T.B.M. and also discharges through the left spillway. Only a small amount of water passes through or around the pile of rock in the right spillway, so there will normally be flow through the left spillway, except during very dry periods.
- 4.2 Maintenance of Dam: Maintenance of the dam is the responsibility of the owners. An inspection or maintenance schedule has not been instituted.
- 4.3 Maintenance of Operating Facilities: There are no operating facilities at the dam.
- 4.4 Warning System: At the present time, there is no warning system or emergency action plan in operation.
- 4.5 Evaluation: Maintenance of the dam in the past has been inadequate. Regular inspections should be made of the dam and appurtenant structures. A thorough check list should be compiled for use by the owner's representative as a guide for the inspections. Maintenance items should be corrected annually. A warning system and emergency action plan should be developed and put into operation.

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NAME OF DAM: BROADDUS DAM

## SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

- 5.1 Design: No design data were available for use in preparing this report.
- 5.2 Hydrologic Information: No rainfall, stream gage, or reservoir stage records are maintained for this dam.
- 5.3 Flood Experience: No records were available. According to local residents, the dam was overtopped during the heavy rains from the remnants of Tropical Storm Agnes in June 1972, but suffered no serious damage.
- 5.4 Flood Potential: The Probable Maximum Flood (PMF), 1/2 Probable Maximum Flood (1/2 PMF), and 100-year flood were developed and routed through the reservoir by use of the HEC-1 DB computer program (Reference 9, Appendix IV) and appropriate unit hydrograph, precipitation, and storage-outflow data. Clark's T<sub>C</sub> and R coefficients for the local drainage areas were estimated from basin characteristics. The rainfall applied to the unit hydrograph was taken from publications by the U.S. Weather Bureau and the National Oceanic and Atmospheric Administration (References 16 and 17, Appendix IV). Rainfall losses for the PMF were estimated at an initial loss of 1.0 inches and a constant loss rate of 0.05 inches per hour thereafter. Rainfall losses for the 100-year flood were estimated at an initial loss of 1.5 inches and a constant loss rate of 0.15 inches per hour thereafter.
- 5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1, paragraph 1.3.3.

Regulation of flow from the reservoir is automatic. Normal flows are maintained by the invert of the control section in the right spillway which is at elevation 151.0 feet T.B.M. A rock pile placed in the right spillway effectively raises the normal pool elevation above the left spillway invert (elevation 152.6 feet T.B.M.) even though a small amount of water does pass through the rock in right spillway.

The outlet discharge capacity was computed by hand; reservoir area was planimetered from the Bowling Green, Virginia, 7.5 minute USGS quadrangle; and storage capacity was computed by the HEC-1 DB program. Outlet discharge capacity and storage capacity curves were computed to elevations above the crest of the dam. All flood routings were begun with the dam at normal pool. Flow through both spillways was included in the routings.

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- 5.6 Overtopping Potential: The probable rise of the reservoir and other pertinent information on reservoir performance are shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

Item	Normal(a)	Hydrographs		
		100-year flood	1/2 PMF	PMF(b)
Peak flow, c.f.s.				
Inflow	2	4228	11,873	23,745
Outflow	2	4139	11,780	23,566
Peak elev., ft. T.B.M.	153.0	158.1	160.1	162.1
Non-overflow section (c) (elev. 155.3 ft. T.B.M.)				
Depth of flow, ft.	-	2.8	4.8	6.8
Average velocity, f.p.s.	-	7.7	10.2	12.1
Total duration of over- topping, hrs.	-	9.5	28.8	35.2
Tailwater elev., ft. T.B.M.	144.6	-	-	-

- (a) Conditions at time of inspection.  
 (b) The PMF is an estimate of flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in a region.  
 (c) Velocity estimates were based on critical depth at control section.

- 5.7 Reservoir Emptying Potential: There are no facilities for draining the reservoir.

- 5.8 Evaluation: Broaddus Dam is a "small" size - "significant" hazard dam requiring evaluation for a spillway design flood (SDF) in the range between the 100-year flood and the 1/2 PMF. Due to the risk involved, the 100-year flood has been selected as the SDF. The SDF was routed through the reservoir and found to overtop the dam by a maximum depth of 2.8 feet with an average critical velocity of 7.7 feet per second. Total duration of dam overtopping would be 9.5 hours. The spillways are capable of passing up to 6 percent of the SDF or 1 percent of the PMF without overtopping the crest of the dam.

Conclusions pertain to present-day conditions and the effect of future development on the hydrology has not been considered.

NAME OF DAM: BROADDUS DAM

## SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: There is no information available on the foundation conditions. The dam is located in the Coastal Plain physiographic province of Virginia. The principal units in this province are consolidated and semi-consolidated sands, silts and clays. The topography consists of rolling hills, gentle slopes, and relief less than 150 feet. The principal deposit in the area of the dam is the Calvert formation, which consists of dark gray, olive, or buff, sandy, diatomaceous clay and fine-grained sand. No evidence of an internal drainage system was found during the inspection. It is not known how the dam is keyed into the foundation. The visual inspection revealed a 3 foot diameter hole and an area of sloughing on the downstream slope above the left spillway, as well as the fact that the downstream slope is very uneven and eroded in places.

### 6.2 Embankment

6.2.1 Materials: There is no information available on the nature of the embankment materials. Examination of the embankment during the visual inspection revealed that the embankment was constructed of grayish to yellowish silty clay. The area soils are generally low-plastic silts and clays. There is no information on any possible zoning of the embankment.

6.2.2 Stability: There are no available stability calculations. The dam is 11.3 feet high and has a crest width of 29 feet. The embankment has an estimated upstream slope of 2H:1V and a measured downstream slope of 2H:1V. The dam is not subject to a rapid drawdown because there are no facilities for draining the reservoir.

According to the guidelines presented in Design of Small Dams by the U.S. Department of the Interior, Bureau of Reclamation, for small homogenous dams with a stable foundation, not subjected to a drawdown and composed of low-plastic fines (CL, ML); the recommended slopes are 3H:1V upstream and 2.5H:1V downstream. The recommended crest width is 12 feet.

NAME OF DAM: BROADDUS DAM



Based on these guidelines, the dam has a width almost 2.5 times that recommended. However, the upstream and downstream slopes are considered to be inadequate.

6.2.3 Seismic Stability: Broaddus Dam is located in Seismic Zone 1. Therefore, according to the Recommended Guidelines for Safety Inspection of Dams, the dam is considered to have no hazard from earthquakes provided static stability conditions are satisfactory and conventional safety margins exist.

6.3 Evaluation: There is insufficient information to adequately evaluate the stability of the dam. However, the visual inspection did reveal a 3 foot diameter hole and an area of sloughing on the downstream slope above the left spillway; sagging of the concrete pipes in the culvert for the left spillway; and the fact that the downstream slope is very uneven and eroded in places. In addition, based on the Bureau of Reclamation guidelines, the upstream and downstream slopes are inadequate. A qualified geotechnical engineering firm should therefore be retained to perform a stability check of the dam.

Also, as described in Section 5 of this report, the dam would be overtopped by the SDF. The SDF would overtop the dam by a maximum depth of 2.8 feet with an average critical velocity of 7.7 f.p.s. Total duration of overtopping would be 9.5 hours. Overtopping flows during the SDF are relatively deep, last 9.5 hours, and the velocity exceeds 6.0 f.p.s., the effective eroding velocity for a vegetated earth embankment. The depth, duration, and rate of overtopping flows are considered detrimental to the embankment.

NAME OF DAM: BROADDUS DAM

## SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

- 7.1 Dam Assessment: There were no engineering data available for use in preparing this report. Deficiencies discovered during the field inspection and office analyses will require further investigation and remedial treatment. The dam and appurtenant structures are generally in fair to poor overall condition. Maintenance of the dam is considered inadequate.

Using the Corps of Engineers' screening criteria for initial review of spillway adequacy, the 100-year flood was selected as the SDF for the "small" size - "significant" hazard classification of Broadus Dam. It has been determined that the SDF would overtop the dam by a maximum depth of 2.8 feet with an average critical velocity of 7.7 f.p.s. Total duration of overtopping would be 9.5 hours. The velocity exceeds 6 f.p.s., the effective eroding velocity for a vegetated earth embankment. The depth, duration, and rate of overtopping flows are considered detrimental to the embankment. The spillways are capable of passing up to 6 percent of the SDF or 1 percent of the PMF without overtopping the crest of the dam.

The spillways are adjudged as inadequate. The spillways have not been adjudged as seriously inadequate since there is not a high probability of loss of life due to large flows downstream of the dam, and because failure of the dam due to overtopping would not significantly increase the probability of loss of life.

There are several problems in the area of the left spillway: a hole and area of sloughing in the embankment above the spillway; sagging of the culvert pipes; leakage from the right-hand pipe; and cracking of the concrete slab downstream of the culvert outlet. The downstream embankment is in poor condition; is eroded in places; is covered with branches, logs, tree stumps, and garbage; has many trees growing on it; and has only a thin cover of wild grass and weeds.

Based on the inadequacy of the spillways, the apparent stability problems in the area of the left spillway, and the poor condition of the downstream slope, the dam is assessed as "unsafe," "non-emergency."

There is no formal warning system or emergency action plan currently in operation.

NAME OF DAM: BROADUS DAM

- 7.2 Recommended Remedial Measures: A qualified geotechnical engineering firm should be retained to perform a stability check of the dam. The owner is required to engage the services of a qualified geotechnical engineering firm within two months of the issuance of the approved Phase I inspection report. The owner is required to have the consultant's report and to have reached an agreement with the Commonwealth of Virginia regarding required remedial measures within six months of the date of the issuance of the approved Phase I inspection report.

The consultant's stability check should include a detailed investigation of the apparent stability problems (sagging of the pipes, development of the hole in the embankment, sloughing, leakage) in the area of the left spillway. The consultant's report should include an explanation of the cause of the problems, as well as recommended remedial measures.

A formal warning system and emergency action plan should be developed and put into effect as soon as possible. The dam should be checked during periods of heavy rainfall until corrective measures are completed. If evidence of piping of embankment materials is detected or if dam overtopping is imminent, a warning should be issued to downstream inhabitants and local public officials. The emergency action plan should list steps to be taken to help prevent failure of the dam in an emergency.

The following repair items should be accomplished as part of the general maintenance of the dam:

- 1) The branches, logs, tree stumps, and garbage on the downstream slope should be removed.
- 2) All trees on the downstream slope should be cut off at ground level. All trees with a trunk diameter greater than 3 inches should also have their root systems removed. The resultant holes should be backfilled with compacted fill.
- 3) The hole in the downstream slope above the left spillway should be filled and compacted and the area of sloughing immediately above the hole should be regraded and compacted.
- 4) All areas of erosion should be regraded and compacted.

NAME OF DAM: BROADDUS DAM

- 5) A good grass cover should be established over the entire embankment.
- 6) The leakage from under the right-hand pipe of the left spillway culvert should be stopped.
- 7) The concrete slabs at the downstream end of the left spillway culvert and under the 24 inch corrugated metal pipe which discharges directly downstream of the culvert should be repaired.
- 8) A staff gage should be installed to monitor reservoir levels above normal pool.

NAME OF DAM: BROADDUS DAM

APPENDIX I

PLATES

## CONTENTS

Location Plan

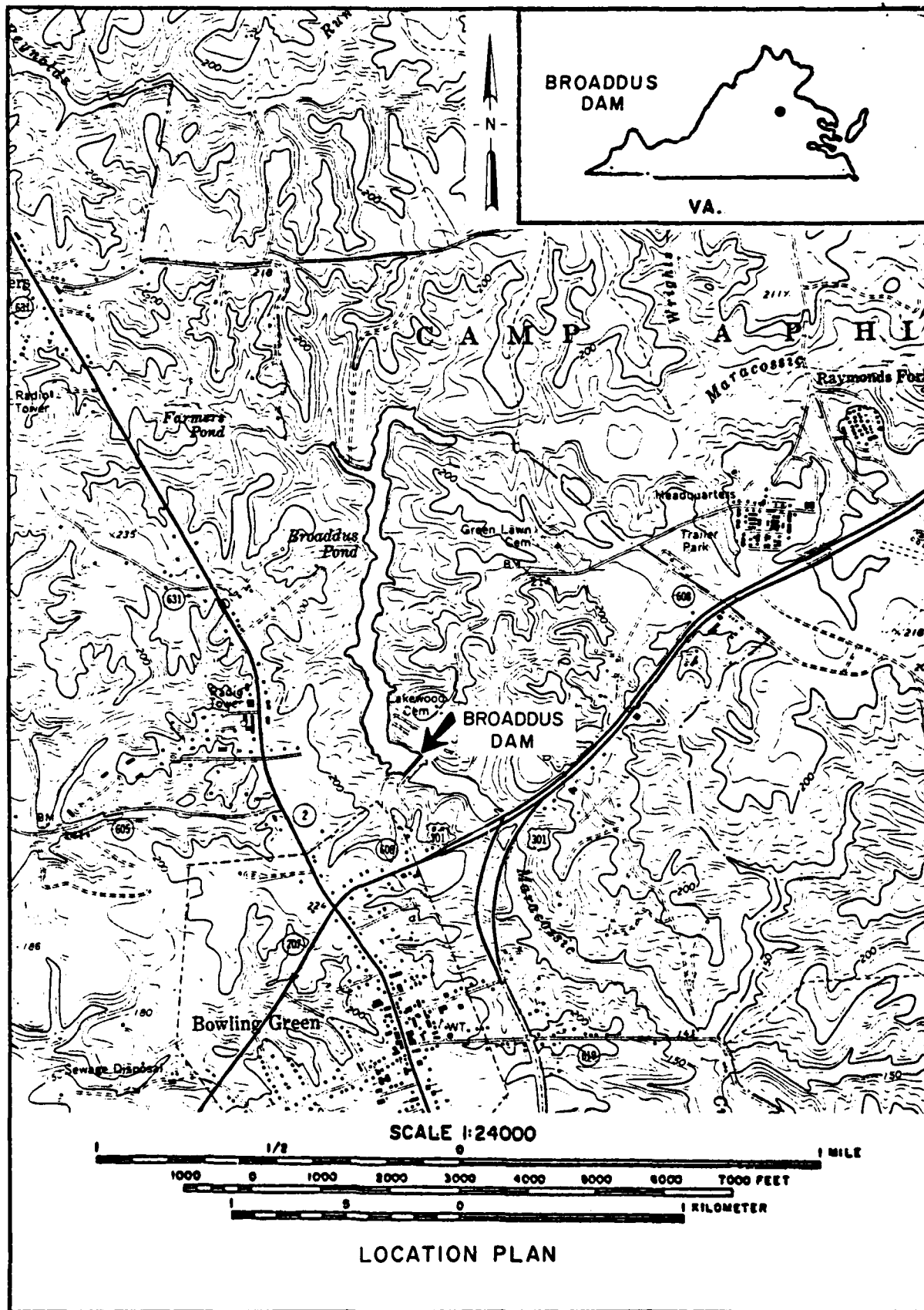
Plate 1: Field Sketch

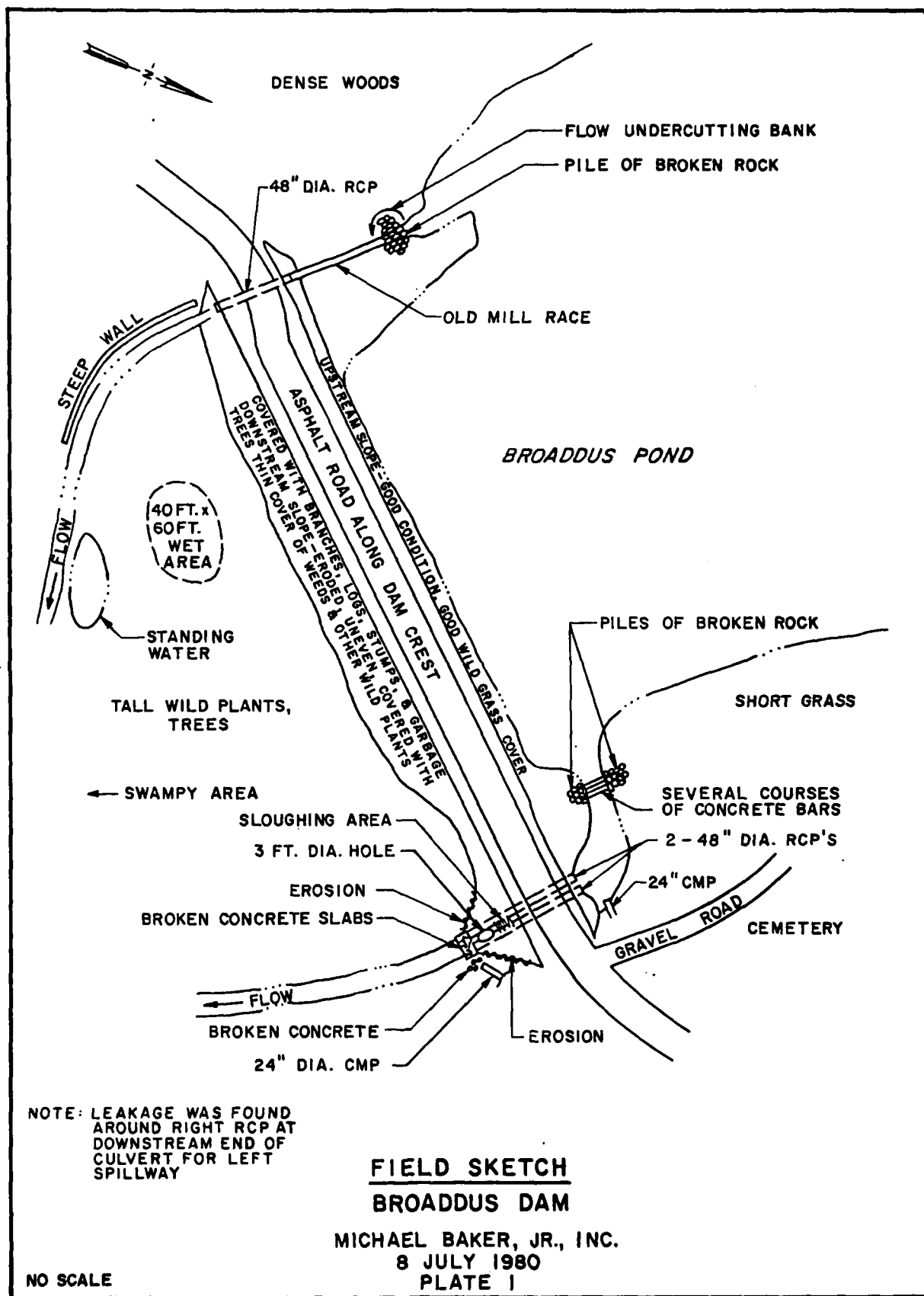
Plate 2: Typical Cross Section

Plate 3: Top of Dam Profile

Plate 4: Section through Left Spillway Control

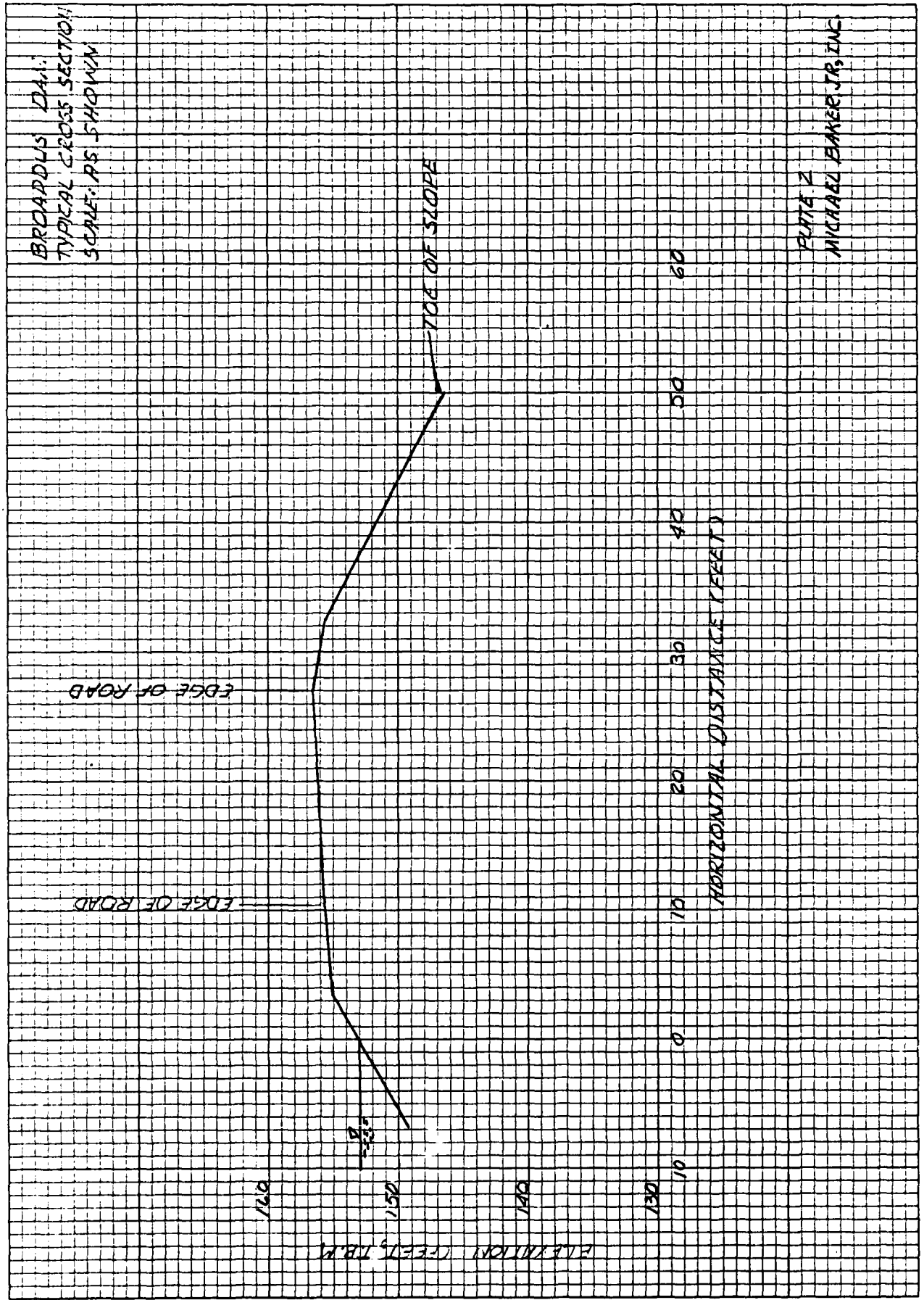
NAME OF DAM: BROADDUS DAM







SEE PROJECT FILE NUMBER



BROADBUSH DAM  
TOP OF DAM PROFILE  
SCALE: AS SHOWN

LOOKING DOWNSTREAM

SEE PLATE 3

SEE PLATE 2

ELEVATION (FEET, T.B.M.)

170  
160  
150  
0

2-28' CMP

NORMAL WATER LEVEL 153.7 B.M.

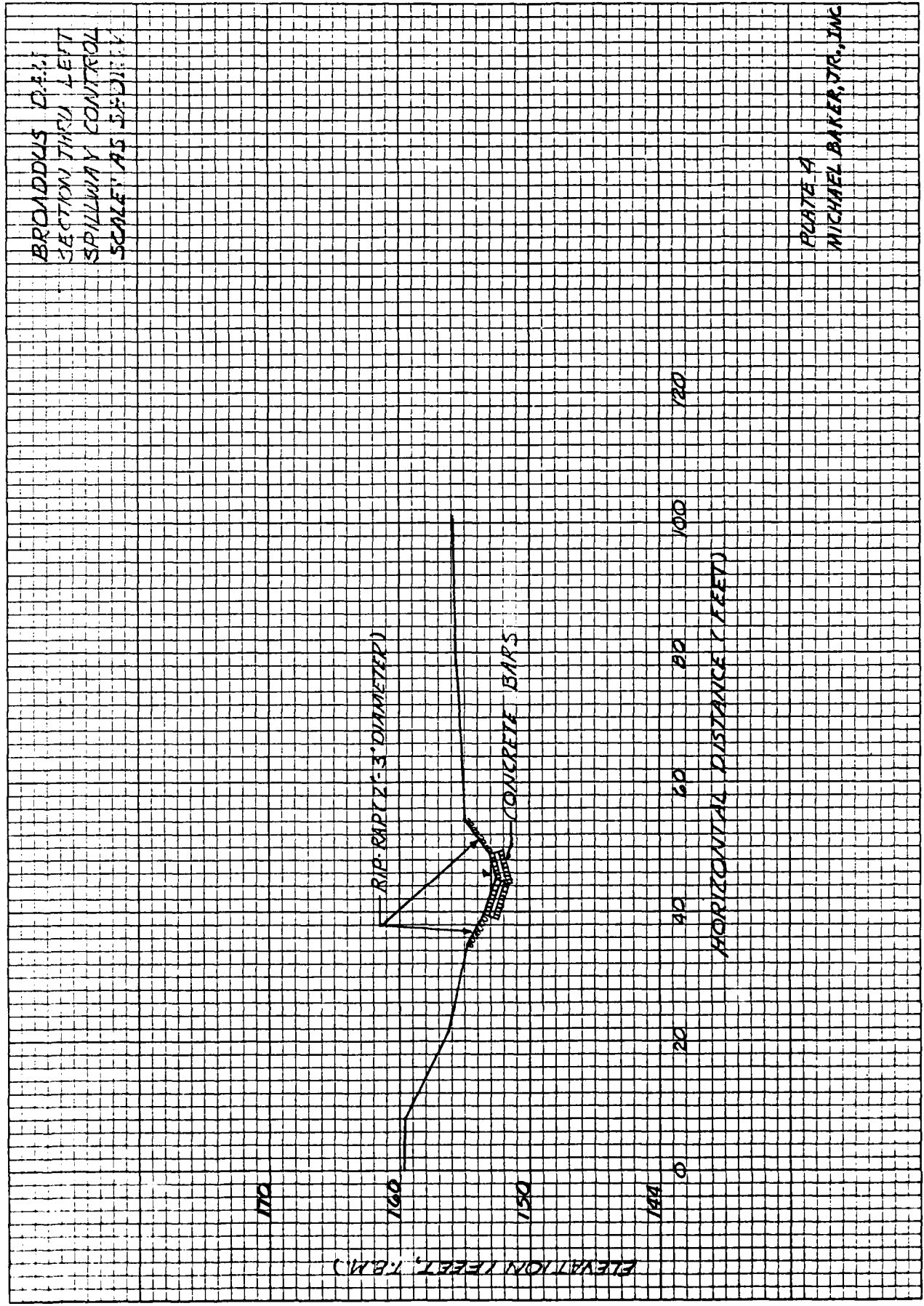
2-28' CMP

HORIZONTAL DISTANCE (FEET)

0 100 200 300 400 500 600 700

PLATE 3

MICHAEL BAKER JR., INC.



BROADBENT D.E.  
SECTION THRU LEFT  
SPILLWAY CONTROL  
SCALE: AS SHOWN

PLATE 4  
MICHAEL BAKER, JR., INC.

APPENDIX II

PHOTOGRAPHS

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- Photo 1: Concrete Bars and Piles of Rock at Left Spillway Control Section, 25 Feet Upstream of Culvert
- Photo 2: Pile of Rock Placed in Right Spillway (Old Mill Race), 80 Feet Upstream of Culvert
- Photo 3: Broken Concrete below 24 Inch Diameter C.M.P., just Downstream from Left Spillway Culvert
- Photo 4: Erosion on Downstream Slope at Right Side of Left Spillway
- Photo 5: Three Foot Diameter Hole on Downstream Slope, above Left Spillway
- Photo 6: Reservoir from Embankment Crest

Note: Photographs were taken on 8 July 1980.

NAME OF DAM: BROADDUS DAM

## **BROADDUS DAM**



**PHOTO 1. Concrete Bars and Piles of Rock at Left Spillway Control Section,  
25 Feet Upstream of Culvert**

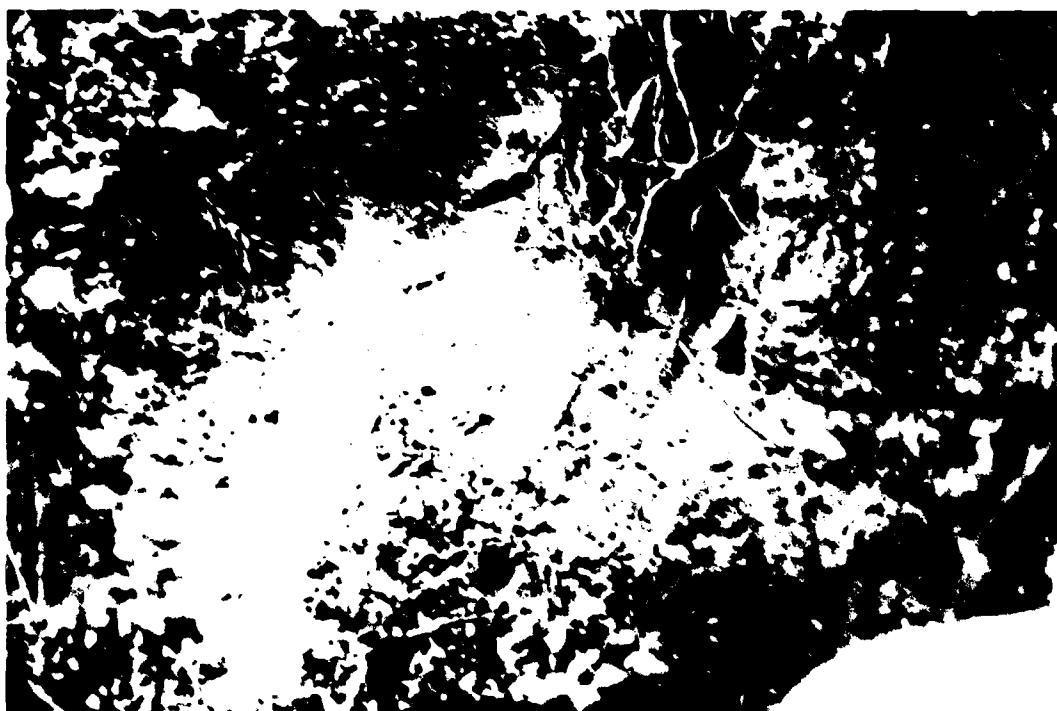


**PHOTO 2. Pile of Rock Placed in Right Spillway (Old Mill Race),  
80 Feet Upstream of Culvert**

# **BROADDUS DAM**

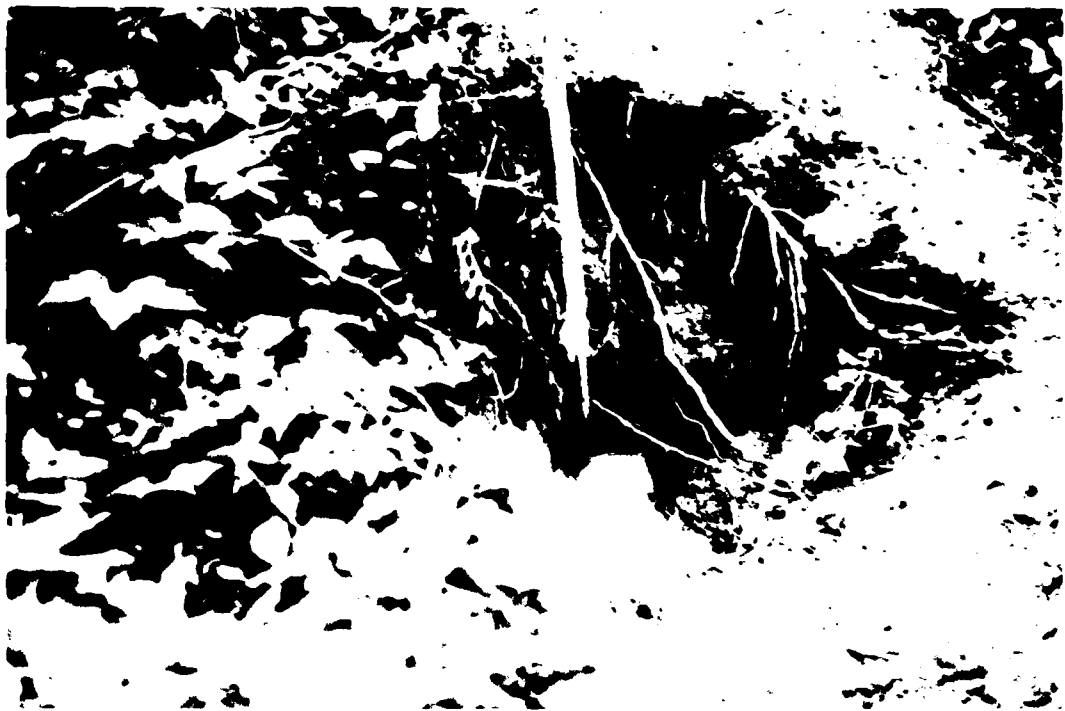


**PHOTO 3. Broken Concrete below 24 Inch Diameter Corrugated Metal Pipe,  
just Downstream from Left Spillway Culvert**

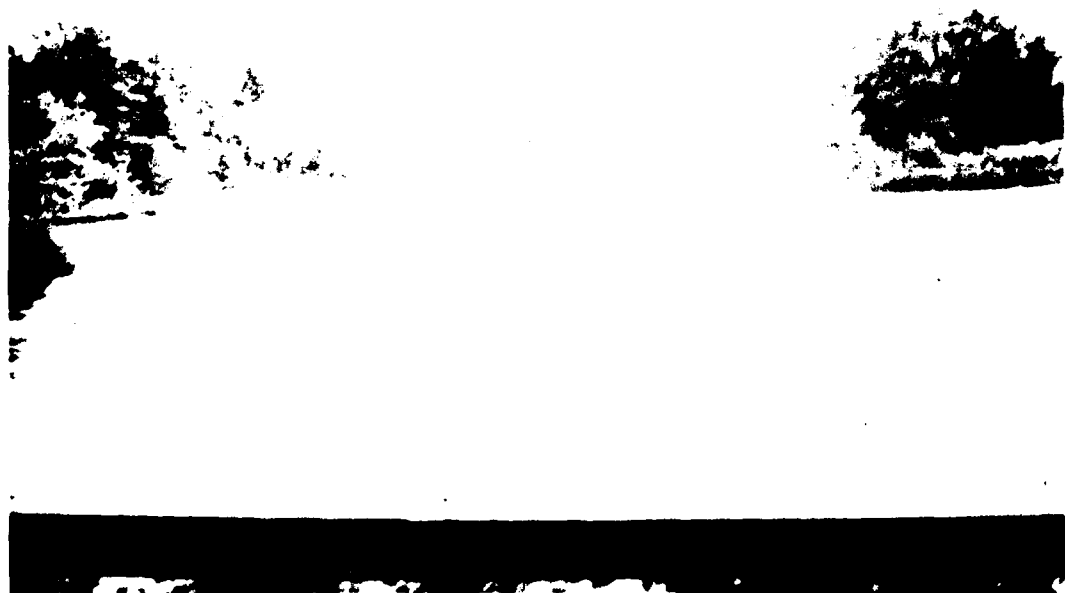


**PHOTO 4. Erosion on Downstream Slope at Right Side of Left Spillway**

## **BROADDUS DAM**



**PHOTO 5. Three Foot Diameter Hole on Downstream Slope,  
above Left Spillway**



**PHOTO 6. Reservoir from Embankment Crest**



APPENDIX III

VISUAL INSPECTION CHECK LIST

Visual Inspection  
Check List  
Phase 1

Name of Dam Broadus Dam County Caroline State Virginia Coordinates Lat. 3803.7

Long. 7220.8

Date of Inspection 8 July 1980 Weather Cloudy, rainy Temperature 75° F.

Pool Elevation at Time of Inspection 153.0 ft.\* T.B.M. Tailwater at Time of Inspection 144.6 ft.\* T.B.M.

\*Elevations were referenced to a temporary bench mark and are approximately M.S.L.

Inspection Personnel:

Michael Baker, Jr., Inc.:

John W. Lightner  
Jeffrey A. Quay  
P.S. Verma

Owner's Representatives:

None

Virginia State Water Control Board:

Leon Mussellwhite

P.S. Verma Recorder

# EMBANKMENT

Name of Dam BROADDUS DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	A hole approximately 3 ft. in diameter by 4 ft. deep has formed in the downstream embankment slope directly above the left spillway. There is an area of sloughing 7 ft. long by 4 ft. wide above the hole.	A stability check should be conducted by a qualified geotechnical engineering firm to determine the cause of the problem and recommend remedial measures.
		The hole should be backfilled and compacted and the area of sloughing should be regraded and compacted.

HH-1-2

UNUSUAL MOVEMENT OR  
CRACKING AT OR BEYOND  
THE TOE

None observed

SLOUGHING OR EROSION OF  
EMBANKMENT AND ABUTMENT  
SLOPES

The downstream embankment slope is eroded in places, particularly in the middle of the dam, and very uneven. The downstream slope is covered with branches, logs, tree stumps, and garbage. Consequently a close inspection was impossible. There are many small- to medium-sized trees on the downstream slope, which has a thin cover of common wild grass and weeds. The upstream slope of the dam has a good cover of wild grass and appears to be in good condition. In general, the abutment slopes appear to be in good condition.

The branches, logs, tree stumps, and garbage on the downstream slope should be removed. All trees on the downstream slope should be cut off at ground level. All trees with a trunk diameter greater than 3 in. should also have their root systems removed. All areas of erosion should be regraded and compacted. A good grass cover should be established over the entire embankment.

# EMBANKMENT

Name of Dam BROADDUS DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	A two-lane asphalt road runs along the crest of the dam. Vertical and horizontal alignment of the crest both appear to be good.	

## RIPRAP FAILURES

There is no evidence of erosion due to wave action, but this may be because the reservoir level was recently raised 2-3 ft.

There is no riprap on the dam.

## EMBANKMENT MATERIALS

The embankment was apparently constructed of gray to yellowish-gray, damp to moist, sandy/silty clay. At the time of inspection (after a heavy rain), it was damp on the upstream slope and moist on the downstream slope.

There is no information available on possible zoning of the embankment or on the existence of a keyway or impervious core.

# EMBANKMENT

Name of Dam BROADDUS DAM

VISUAL EXAMINATION OF		OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT		There is minor erosion at the junction of the downstream embankment slope and left abutment, on the left side of the left spillway. Otherwise, the junctions of the embankment and abutments appear to be in good condition.	The area of erosion at the junction of the downstream embankment slope and left abutment should be regraded and reseeded.
ANY NOTICEABLE SEEPAGE		A wet area approximately 40 ft. long by 60 ft. wide was found approximately 25 ft. downstream of the toe and 100 ft. from the right abutment. A small area of standing water was found along the right abutment 50 ft. downstream of the toe. No seeps were found on the downstream slope or at the toe.	Some of the wetness may have been the result of heavy rain immediately preceding the inspection. According to a local resident, the area 50 ft. downstream of the crest is normally dry. The standing water further downstream appears to be overflow from the discharge channel of the right spillway.
STAFF GAGE AND RECORDER	None		A staff gage should be installed to monitor reservoir levels above normal pool.

DRAINS  
No evidence of an internal drainage system was found during the inspection.

Name of Dam: BROADDUS DAM

UNGATED SPILLWAYS

VISUAL EXAMINATION OF		OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEFT SPILLWAY	<p>The approach channel is approximately 10 ft. long, with an adverse slope of approximately 4H:1V. Several courses of concrete bars (8 in. by 6 in. by 10 ft.) have been placed at the control section to raise the level of the reservoir. Piles of broken gneiss rock, approximately 2-3 ft. high, have been placed on both sides of the concrete bars. The individual pieces of rock are angular and 1-3 in. long. After flowing over the control section, the discharge flows along an earth channel with a natural rock bottom for approximately 25 ft. and then enters a culvert which passes under the dam, adjacent to the left abutment. The culvert consists of two, 51 ft. long, 48 in. diameter reinforced concrete pipes. After leaving the culvert, the discharge flows over a concrete slab approximately 10 ft. long, then down a natural channel approximately 100 ft. long. The discharge then enters a swampy area with no well-defined channel. Approximately 10 ft. upstream of the culvert inlet there is a 24 in. diameter C.M.P. which discharges surface runoff from the left hillside into the spillway. The concrete slab downstream of the culvert outlet is cracked and broken. There is moderate erosion on the downstream embankment slope on both sides of the culvert. Both of the concrete pipes are curved, with the concave side upward, as if they have sagged since they were installed. At the time of inspection, water was leaking from under the bottom of the right-hand pipe. There is another 24 in. diameter C.M.P. which discharges from the left abutment directly</p> <p>(continued next page)</p>		
	<p>During periods of high reservoir levels, erosion is likely to occur at the control section. The piles of rock have been placed to prevent erosion, but the individual pieces appear to be small enough to be carried away by fast-moving water. The areas of erosion should be regraded.</p> <p>Further investigations to determine if there is a stability problem in the area of the left spillway should be made without delay. The leakage from under the right-hand pipe should be stopped. The concrete slabs at the downstream end of the left spillway culvert and under the 24 in. C.M.P. should be repaired.</p>		

# UNGATED SPILLWAYS

Name of Dam: BROADDUS DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEFT SPILLWAY (continued)	downstream of the culvert outlet. At the time of the inspection, this pipe was dry. Erosion has occurred around this pipe, the last 5 ft. of which are now exposed and unsupported. The concrete slab which originally supported this pipe has eroded and washed away.	
RIGHT SPILLWAY	<p>The dam was originally constructed to provide water to power a mill. The right spillway is the old mill race. The approach channel is approximately 20 ft. long by 4 ft. wide, with no appreciable slope. A pile of broken gneiss rock has been placed in and on both banks of the mill race to raise the level of the lake. The individual pieces of rock are angular and vary in length from less than 1 in. to 10 in. At the time of inspection, water was flowing through the pile of rock and also appeared to be undercutting the bank and flowing around the pile of rock. Water passing the pile of rock flows along a narrow channel with a very gentle slope for a distance of approximately 80 ft. prior to entering a culvert which passes under the dam, adjacent to the right abutment. The culvert consists of a single, 30 ft. long, 48 in. diameter reinforced concrete pipe. Water emerging from the culvert drops 4 ft. into a narrow channel, which continues for approximately 100 ft. before disappearing into a swampy area with no well-defined channel. The right spillway appears to be in good condition except where the water is undercutting the bank in the area of the rock pile.</p>	<p>The water which is undercutting the bank and flowing around the rock pile may eventually cause the bank to collapse, which may lower the reservoir level.</p>

# UNGATED SPILLWAYS

Name of Dam: BROADDUS DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
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BRIDGE AND PIERS	Not Applicable	
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EMERGENCY GATES	There are no emergency gates or other facilities for draining the reservoir.	The reservoir level could be drawdown a few ft. by removing the concrete bars at the left spillway control section.
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# INSTRUMENTATION

Name of Dam: BROADDUS DAM

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	No permanent markers were found.	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

# RESERVOIR

Name of Dam: BROADDUS DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	<p>The slopes surrounding the reservoir are gentle. There is a small cemetery on the left side of the reservoir immediately above the dam; this area has a good cover of short grass. The rest of the slopes around the reservoir are densely wooded. The slopes appear to be in good condition with no evidence of erosion.</p>	
SEDIMENTATION	<p>The extent of sedimentation was not directly observed. It is not expected to be significant.</p>	<p>According to a local resident, the reservoir has an average depth of 6-7 ft.</p>

# DOWNSTREAM CHANNEL

Name of Dam: BROADDUS DAM

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The discharge channels of both spillways are well-defined with no obstructions for a short distance below the dam. They then enter a swampy area where no well-defined channel exists.	
SLOPES	There is no appreciable slope in the swampy area downstream of the dam. The side slopes are heavily wooded.	
APPROXIMATE NO. OF HOMES AND POPULATION	There are 3 houses, with an estimated population of 12, approximately 1.3 miles below the dam. U.S. Route 301, a four-lane divided highway, crosses the stream on an embankment between the houses and the dam, and would greatly attenuate any flood wave resulting from failure of the dam.	Loss of human life in the event of a dam failure is not considered highly probable.

APPENDIX IV

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#### GENERAL REFERENCES

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NAME OF DAM: BROADDUS DAM

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